



IJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: VI Month of publication: June 2018

DOI: <http://doi.org/10.22214/ijraset.2018.6061>

www.ijraset.com

Call:  08813907089

E-mail ID: ijraset@gmail.com

Study of the Optical Property and Applications of TiO₂-SiO₂ Nano Composites in Textile

Navneet Kumari¹, Dr Sunil Rohilla²

¹Department of Physics, Mewar University Gangrar, Chittorgarh- 312901 (Rajasthan), India

²Materials Science Lab, Department of Applied Physics, TIT&S Engg. College, Birla Colony Bhiwani-127021, India

Abstract: Nanocomposite consisting of Titanium dioxide (TiO₂) and silicon dioxide (SiO₂) was prepared by the wet chemical method. and their use in the photocatalytic process has been proposed as an alternative to the conventional TiO₂ catalysts (unique textural and structural properties). The prepared samples then characterized by X-ray diffraction, UV-Vis spectroscopy, Fourier transform infrared spectroscopy. TiO₂ nanoparticles acquire complete crystalline anatase phase on thermal treatment of as-prepared anatase TiO₂ at 450°C. The crystallite size of the as-synthesized samples was calculated by Scherrer's formula. And the nanocomposite used in the textile due to its unique and valuable properties. TiO₂-SiO₂ nanocomposites makes textile to become anti bacterial and wrinkle resistance.

Keywords: Nanocomposites, Binary oxides, characterization, Co-precipitation

I. INTRODUCTION

Nano crystalline TiO₂ has solicits continuous consideration due to its versatile applications in optical devices, sensors, catalysis and photocatalysis etc. Titania based materials are of great consequence for a wide variety of applications because of the interest in their specific physical and chemical properties. The nanocomposite materials (binary mixed oxides) has been widely prepared by coprecipitation method and recognized as one of the promising research area. The chemical properties of the titanium dioxide, in addition to its morphology, are intimately related to the crystallographic structure of the solid (e.g. rutile, anatase, brookite) TiO₂ nanoparticles acquire complete crystalline anatase phase on thermal treatment of as-prepared anatase TiO₂ at 450°C. Anatase-rutile mixed phase and rutile phase are achieved by annealing anatase TiO₂ at 700°C and 950°C respectively. [1,2]. By its nature, crystal domain of nanometric size can be capture for the anatase peculiar, although crystal transition from anatase to rutile results in a enormous increase in crystal domain size [3], and consequently into an important decrease in accessible specific surface area (SSA). Thus, the physical properties of the rutile form of titania become hardly compatible with a use as catalyst support [4]. The use of the anatase form of titania is then most often reported in academic studies as catalyst support [5-7] although that the use of titania, either anatase or rutile form, remains limited for high temperature reactions. TiO₂ nanoparticles have large specific surface areas and high catalytic performance in which reactions take place on the TiO₂ surface. However, their effective monetary applications are counteracted by two serious disadvantages. Firstly, ultrafine powders will cluster into larger particles, appear in an adverse issue on catalyst performance. Secondly, the separation and recovery of TiO₂ powders from wastewater are difficult [8]. Thirdly, TiO₂ photocatalysis requires ultraviolet (UV) radiation whose energy exceeds the band gap of 3.2 eV (λ — 380 nm) of the anatase crystalline phase, utilizing only a very small fraction of sunlight. Titania (TiO₂) based materials are of great interest for a wide variety of applications as air purification [10], self-cleaning surfaces [9]. Therefore, several groups have investigated titania coating on high surface area supports such as silica or alumina [10]. Incorporation of SiO₂ into the TiO₂ would reduce the particle size, increase the specific surface area, and suppress the TiO₂ phase transformation from anatase to rutile [11]. The chemical properties of titanium dioxide with silica, are intimately related to the crystallographic structure (e.g. rutile, anatase, brookite) [12-13]. The anatase form of titania/silica (TiO₂-SiO₂) composite have received considerable attention due to their unique properties, such as stability, low thermal expansion coefficient, and high refractive index, which lead to their uses in a wide variety of applications as X-ray imaging, display monitors, laser, amplifiers for fiber-optic communication [14], non-toxicity, photocatalytic property [15], catalyst support [16-20], and optoelectronic devices etc. Many synthetic approaches have been employed to prepare TiO₂/SiO₂ binary oxides as Coprecipitation process has been proved to be an efficient method to prepare ultra-fine particles dispersed in different matrices.

II. EXPERIMENTAL

A. Synthesis of TiO₂ Nanoparticles

The solution of titanium (IV) isopropoxide $Ti(OC_3H_7)_4$ was added dropwise in isopropyl alcohol and stirred for 45 min. The metal oxide was produced by increasing the pH by dropwise addition of 1 N NH_3 solution. The resultant solution was stirred for 36 h and kept for 2 day aging. The solution was filtered after 2 days of aging in order to remove any particulates. The precipitate was washed several times with distilled water and dried in oven for 30 h to remove the solvent. Removal of residual and the stabilization of the materials were carried out by calcination for 4 h at $450^\circ C$.

B. Synthesis of SiO_2 Nanoparticles

The solution of tetra-ethylorthosilicate $Si(OC_2H_5)_4$ was added dropwise in isopropyl alcohol and stirred for 45 min. The metal oxide was produced by increasing the pH by dropwise addition of 1 N NH_3 solution. The resultant solution was stirred for 36 h and kept for 2 day aging. The solution was filtered after 2 day of aging in order to remove any particulates. The precipitate was washed several times with distilled water and dried in oven for 30 h to remove the solvent. Removal of residual and the stabilization of the materials were carried out by calcination for 4 h at $450^\circ C$

C. Synthesis of TiO_2/SiO_2 Nanocomposites

The solution of titanium (IV) isopropoxide $Ti(OC_3H_7)_4$ should be added dropwise in isopropyl alcohol and stirred. A solution of tetra-ethylorthosilicate $Si(OC_2H_5)_4$ in isopropyl alcohol was added to the reaction medium and stirred for 45 min. The resultant solution was stirred for 36 h and kept for 2days aging. The solution was filtered after 2 days of aging in order to remove any particulates. The precipitate was washed several times with distilled water and dried in oven for 30 h to remove the solvent. Removal of residual organics and the stabilization of the materials were carried out by calcination for 4 h at $450^\circ C$.

III. CHARACTERIZATION

A. Xrd

The crystal structure of the powder was studied by powder X-ray diffraction In order to determine the crystallite size and lattice constant, XRD patterns of samples were recorded by using a Philips X-ray powder diffractometer PW/1710 having GIXRD geometry; with Ni filter, using monochromatic CuK radiation of wavelength 1.5418\AA at 50KV and 40mA.. The average crystallite sizes of TiO_2 , SiO_2 nanoparticles and TiO_2/SiO_2 nanocomposites were determined according to Scherrer's equation $D = 0.94\lambda/\beta \cos\theta$, where D is crystallite size, λ is wavelength, β is full width half maximum, and θ is angle of diffraction. The Fourier transform infrared spectra of the samples can be studied using Perkin-Elmer infrared spectrophotometer. The spectrum is recorded in the range of wavenumber $500-4,000\text{ cm}^{-1}$. The UV-Vis spectra were obtained using UV-Vis-NIR spectrophotometer. The spectra were recorded at room temperature in the range $200-1,000\text{ nm}$. In fig.1 XRD pattern of the as-synthesized (a) TiO_2 nanoparticles, (b) SiO_2 nanoparticles. While in Figure 2 XRD pattern of the TiO_2/SiO_2 nano composite has been shown.

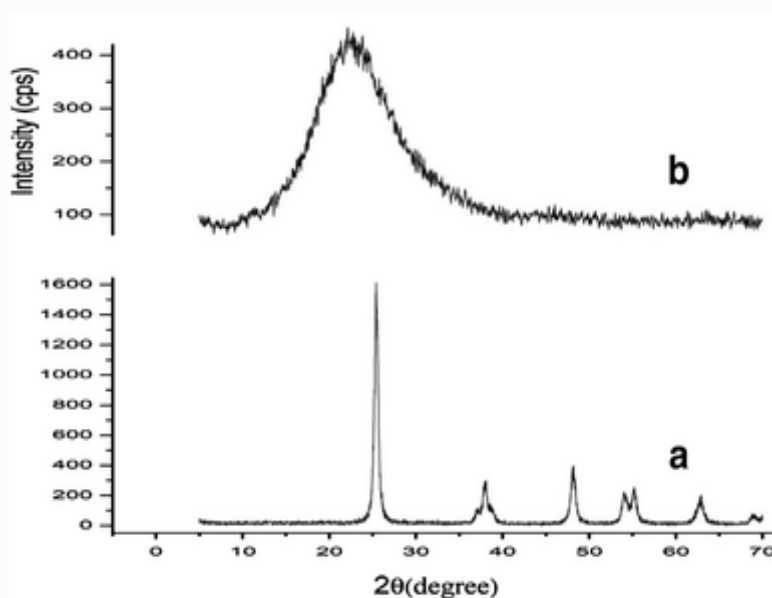


Figure 1 XRD pattern of the as-synthesized (a) TiO_2 nanoparticles, (b) SiO_2 nanoparticles.

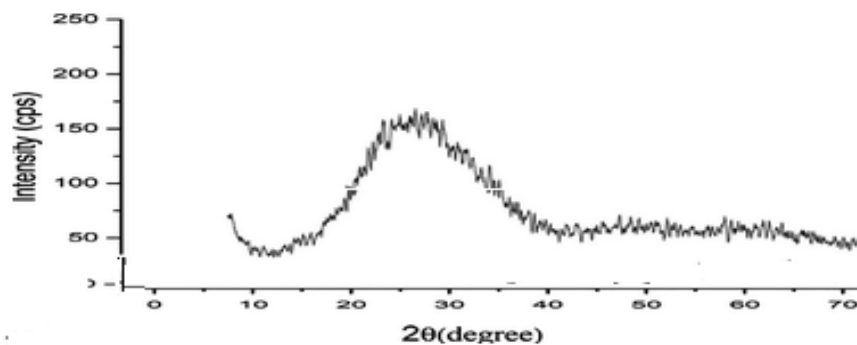


Figure 2 XRD pattern of the TiO₂/SiO₂ nano composite

Table 1 particle size and optical band gap of the as-synthesized samples

Sample	2θ (degree)	β (rad)	Crystallite size (nm)	E _g (eV)
TiO ₂	25.38	0.029655	4.63	3.54
SiO ₂	22.42	0.22239	0.64	3.85
TiO ₂ /SiO ₂	25.48	0.281549	0.51	3.35

In table 1 β is Full width half maximum, θ angle of diffraction, E_g optical band gap

B. UV-Vis Spectrum

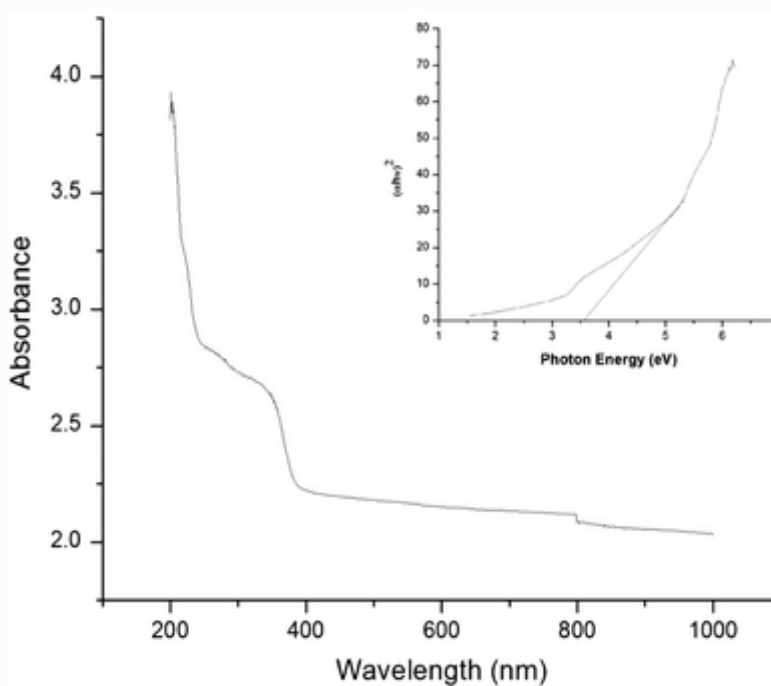


Figure 3. UV-Vis spectrum of the as-synthesized TiO₂ nanoparticles inset shows the corresponding plot of photon energy versus $(\alpha h\nu)^2$

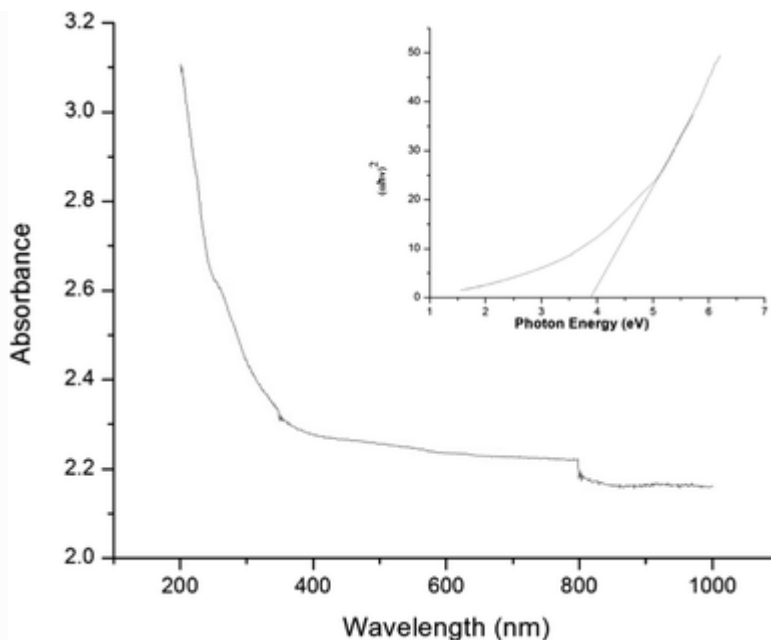


Figure 4 UV-Vis spectrum of the as-synthesized SiO₂ nanoparticles *inset* shows the corresponding plot of photon energy versus $(ahv)^2$

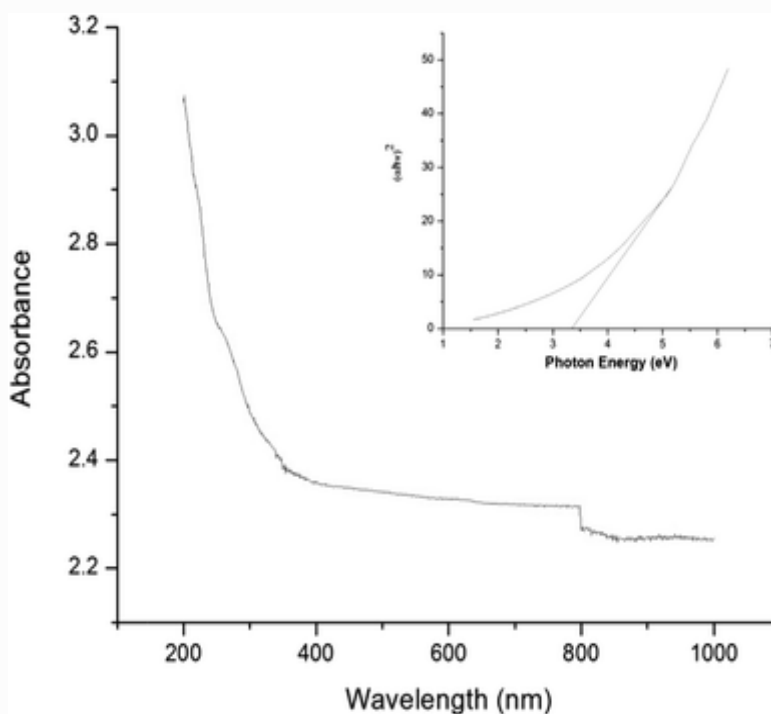


Figure 5 shows the UV-Vis spectrum of the as-prepared TiO₂/SiO₂ nanocomposite and while *inset* shows the corresponding plot of photon energy versus $(ahv)^2$

UV-Vis absorption study should be carried out in order to characterize the optical absorbance of the sample. The absorption spectra of the as-synthesized titanium dioxide, silica dioxide (nanoparticles) and TiO₂/SiO₂ nanocomposite has been shown in Figs 3, 4, and fig. 5. The optical band gap may be calculated by plotting $(ahv)^2$ versus photon energy (hv) based on the relation

$$ahv = A(hv - E_g)^{n/2} \tag{1}$$

given in equation(1), where α is the absorption coefficient, A denotes a constant parameter, E_g is the band gap and n is the exponent, which is depending on quantum selection rule for a particular material. For a direct transition, $n = 1$. From the above relation, the intercept of the tangent on the photon energy axis reciprocate to optical band gap. From the $(\alpha h\nu)^2$ versus photon energy ($h\nu$) plots, the optical band gaps E_g for all the three synthesized samples were estimated and tabulated in Table 1. Figure 6 shows the UV-Vis spectrum of the as-synthesized samples. All the three as-synthesized samples show similar absorption pattern in which the TiO_2/SiO_2 nanocomposite shows better absorbance in visible range compared to TiO_2 and SiO_2 nanoparticles

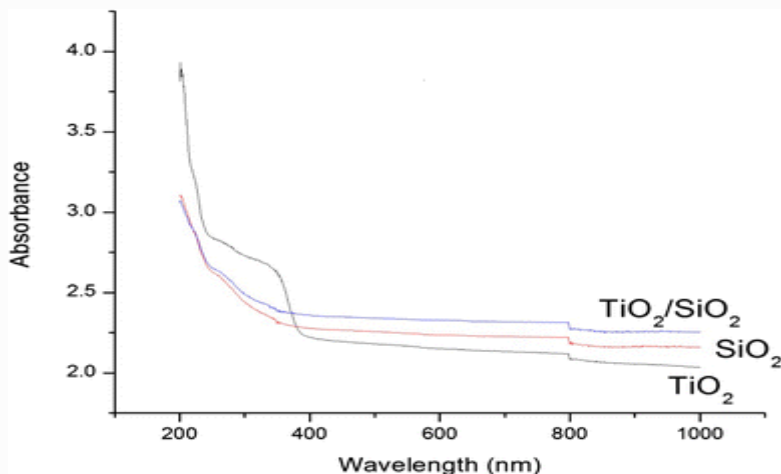


Figure 6 UV-Vis spectrum of the as-synthesized TiO_2 , SiO_2 nanoparticles and TiO_2/SiO_2 nanocomposite

C. Ftir

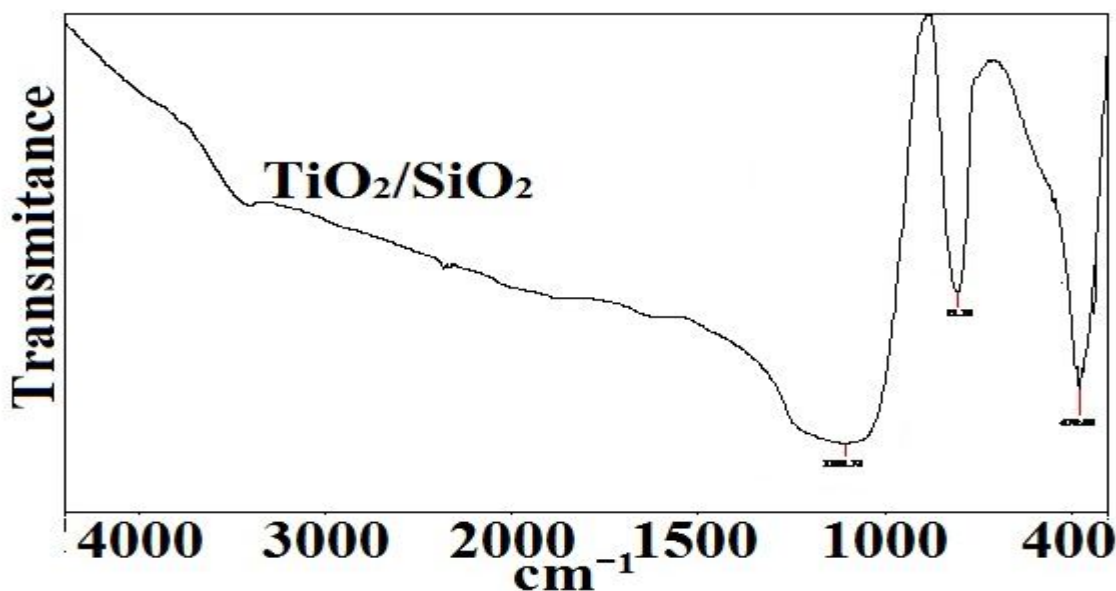


Figure 7. Shows FTIR for TiO_2 and SiO_2 nano composites.

Fig. 7 shows the FTIR spectrum of samples. Fourier transform infrared spectroscopy is a technique which enables us to identify the organic, inorganic materials and especially the presence of impurity phase in natural or synthesized materials. In Fig. 5 peak at 1647.45cm^{-1} corresponds to the bending vibration of the O-H of absorbed water. The peaks near 1098.87 cm^{-1} & 797.74 cm^{-1} correspond to asymmetric and symmetric vibrations of Si-O-Si linkage. The band at 470.09 cm^{-1} assigned to the Si-O-Si bending mode. The band at around 476.53 cm^{-1} can be attributed to the Ti-O and Si-O vibrations, implying the formation of TiO_2 and SiO_2

[16]. The peaks at 1103.73 cm^{-1} and 805.16 cm^{-1} attributes to the asymmetric and symmetric Si-O-Si stretching vibrations. A small peak related to Ti—O—Si linkages appeared at 960 cm^{-1} affirming the bonding between Ti and Si.

IV. APPLICATIONS IN TEXTILES

A. Anti-Bacterial And Wrinkle Resistance

The antibacterial activity of titanium dioxide nanoparticles in textiles has been shown based on degrading organic materials by photocatalytic reaction. For imparting anti-bacterial properties, titanium dioxide is used.

Metallic ions and compounds can display a certain degree of sterilizing effect. It has been investigated that part of the oxygen in the air or water turned into active oxygen by process of catalysis with the metallic ion, thereby dissolving the organic substance, able to create a sterilizing effect [21]. By applying nano-sized particles, we can increase the particles density (per unit area), and by doing so anti-bacterial effects will be maximized. TiO_2 also acts as a photocatalyst, once it is illuminated by light having energy higher than its band gaps, the electrons in TiO_2 will jump from the valence band to the conduction band, and the electron (e^-) and electric hole (h^+) pairs will form on the surface of the photocatalyst. The electrons and oxygen combine into O_2^- , the holes and water will generate hydroxyl radicals. When the organic compound falls on the surface of the photocatalyst it will combine with O_2^- and OH^- respectively (because of unstable chemical), and turn into carbon dioxide (CO_2) and water (H_2O). Such type of reaction is known as 'oxidation-reduction', [22]. The photocatalyst may become able to decompose common organic matters in the air such as odor molecules, bacteria, and viruses. We know that Resin is commonly used, to impart wrinkle resistance to a fabric in conventional methods. But this will transport a pratfall in the tensile strength of the fiber, abrasion resistance, water absorbency and dyeability, as well as breathability. To obtain better result TiO_2 [23, 24] and SiO_2 [25] nanoparticle can be used to improving the wrinkle resistance of cotton and silk respectively, in place of resin. TiO_2 can be antiquated with carboxylic acid concealed by UV irradiation, which is used to catalyze the cross-linking reaction between the cellulose molecule and the acid.

V. CONCLUSION

Nanocomposite Fig. 7 shows the FTIR spectrum of samples. Fourier transform infrared spectroscopy is a technique which enables us to identify the organic, inorganic materials and especially the presence of impurity phase in natural or synthesized materials. In Fig. 5 peak at 1647.45 cm^{-1} corresponds to the bending vibration of the O-H of absorbed water. The peaks near 1098.87 cm^{-1} & 797.74 cm^{-1} correspond to asymmetric and symmetric vibrations of Si-O-Si linkage. The band at 470.09 cm^{-1} assigned to the Si-O-Si bending mode. The band at around 476.53 cm^{-1} can be attributed to the Ti-O and Si-O vibrations, implying the formation of TiO_2 and SiO_2 [16]. The peaks at 1103.73 cm^{-1} and 805.16 cm^{-1} attributes to the asymmetric and symmetric Si-O-Si stretching vibrations. A small peak related to Ti—O—Si linkages appeared at 960 cm^{-1} affirming the bonding between Ti and Si.

VI. APPLICATIONS IN TEXTILES

A. Anti-Bacterial And Wrinkle Resistance

The antibacterial activity of titanium dioxide nanoparticles in textiles has been shown based on degrading organic materials by photocatalytic reaction. For imparting anti-bacterial properties, titanium dioxide is used. Metallic ions and compounds can display a certain degree of sterilizing effect. It has been investigated that part of the oxygen in the air or water turned into active oxygen by process of catalysis with the metallic ion, thereby dissolving the organic substance, able to create a sterilizing effect [21]. By applying nano-sized particles, we can increase the particles density (per unit area), and by doing so anti-bacterial effects will be maximized. TiO_2 also acts as a photocatalyst, once it is illuminated by light having energy higher than its band gaps, the electrons in TiO_2 will jump from the valence band to the conduction band, and the electron (e^-) and electric hole (h^+) pairs will form on the surface of the photocatalyst. The electrons and oxygen combine into O_2^- , the holes and water will generate hydroxyl radicals. When the organic compound falls on the surface of the photocatalyst it will combine with O_2^- and OH^- respectively (because of unstable chemical), and turn into carbon dioxide (CO_2) and water (H_2O). Such type of reaction is known as 'oxidation-reduction', [22]. The photocatalyst may become able to decompose common organic matters in the air such as odor molecules, bacteria, and viruses. We know that Resin is commonly used, to impart wrinkle resistance to a fabric in conventional methods. But this will transport a pratfall in the tensile strength of the fiber, abrasion resistance, water absorbency and dyeability, as well as breathability. To obtain better result TiO_2 [23, 24] and SiO_2 [25] nanoparticle can be used to improving the wrinkle resistance of cotton and silk respectively, in place of resin. TiO_2 can be antiquated with carboxylic acid concealed by UV irradiation, which is used to catalyze the cross-linking reaction between the cellulose molecule and the acid.

VII. CONCLUSION

Nanocomposite consisting of Titanium dioxide (TiO₂) and silicon dioxide (SiO₂) was prepared by the wet chemical method. From the XRD pattern and FTIR data, we are able to find that TiO₂ nanoparticles gain complete crystalline anatase phase on thermal analysis at 450°C. Anatase-rutile mixed phase and rutile phase are achieved by annealing anatase TiO₂ at 700°C and 950°C respectively. At angle (2 thetas) 25.38 the particle size is 4.63 while at an angle (2 thetas) 25.48 the particle size becomes .51nm. TiO₂ nano-particles also shows anti-bacterial activity in textiles. And also shows the wrinkle resistance activity in cotton and silk respectively. When TiO₂ consolidate with silica matrix the band gap gets enhanced. Which makes it able to used in textile industries for strengthening the textile properties like the antibacterial and anti wrinkle.

VIII. ACKNOWLEDGEMENTS

Authors thankfully acknowledges Director(Prof. Dr. G. K. Tyagi of TIT&S Bhiwani, India for constant encouragement and Dr. P. Aghamkar for fruitful discussion. Thanks are due to UGC, New Delhi for financial assistance anti wrinkle.

IX. ACKNOWLEDGEMENTS

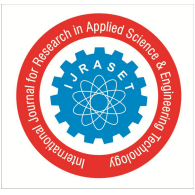
Authors thankfully acknowledges Director(Prof. Dr. G. K. Tyagi of TIT&S Bhiwani, India for constant encouragement and Dr. P. Aghamkar for fruitful discussion. Thanks are due to UGC, New Delhi for financial assistance

REFERENCES

- [1] T. Sreethawong, Y. Suzuki, S.Yoshikawa, "Synthesis, characterization, and photocatalytic activity for hydrogen evolution of nanocrystalline mesoporous titania prepared by surfactant-assisted templating sol-gel process". *J Solid State Chem*, 178: 329–338, 2005
- [2] S.Kato, F.Masuo, "Titanium dioxide-photocatalyzed oxidation. I. Titanium dioxide-photocatalyzed liquid phase oxidation of tetralin", *Kogyo Kagaku Zasshi*, 67: 42–50, 1964
- [3] D.R.Coronado, G.R.Gattorno, M.E.Pesqueira, C.Cab, R.Coss, R.G.Oskam. "Phase pure TiO₂nanoparticles: anatase, brookite and rutile", *Nanotechnology* 19: 145605. 10.1088/0957-4484/19/14/145605, 2008
- [4] W.Qin, J.A.Szpunar, "Origin of lattice strain in nanocrystalline materials". *Phil Mag Lett* 85: 649–656, 2005
- [5] K.Yanagisawa, J.Ovenstone, "Crystallization of anatase from amorphous titania using the hydrothermal technique: effects of starting material and temperature". *J Phys Chem B* 103: 7781–7787. 10.1021/jp990521c, 1999
- [6] J. Zhang, Q.Xu, M.Li, Z. Feng, C. Li, "UV Raman spectroscopic study on TiO₂. II. Effect of nanoparticle size on the outer/inner phase transformation". *J Phys Chem C* 113: 1698–1704. 10.1021/jp808013k, 2009.
- [7] S. Lei, W. Duan, "Highly active mixed-phase TiO₂ photocatalysts fabricated at low temperature and the correlation between phase composition and photocatalytic activity". *J Environ Sci* 20: 1263–1267. 10.1016/S1001-0742(08)62219-6, 2008
- [8] Y. Liu, J. Li, B. Zhou, H. Chen, Z. Wang, W. Cai, "A TiO₂-nanotube-array-based photocatalytic fuel cell using refractory organic compounds as substrates for electricity generation". *Chem Commun* 47: 10314–10316. 10.1039/c1cc13388h, 2011
- [9] D.C.M. Dutoit, U. Go. bel, M. Schneider, A. Baiker, "Titania–Silica Mixed Oxides: V. Effect of Sol-Gel and Drying Conditions on Surface Properties", *J. Catal.* 164 ,433–439, 1996, 199
- [10] Ki Do Kim, Hyun Joo Bae, Hee Taik Kim, "Synthesis and growth mechanism of TiO₂-coated SiO₂ fine particles, *Colloids and Surfaces*" A: *Physicochem.Eng. Aspects* 221 (2003) 163-173, 2003
- [11] JMeng Xiaqi, Li Lianqiang, Zou Kaishun, Liu Juncheng, "The effect of SiO₂ on TiO₂ up-conversion photoluminescence film". *Optical Materials* 37 (2014) 367–370, 2014
- [12] D. Reyes-Coronado, G. Rodriguez-Gattorno, M. Espinosa-Pesqueira, J.M. Gardner, G.J. Meyer, G. s Oskam, "Synthesis and characterization of TiO₂ nanoparticles: Anatase, brookite, and rutile", *Proceeding of SPIE* (2007) 6650, 2007
- [13] M. Koelsch, S. Cassaignon, J.F. Guillemoles, J.P. Jolivet, "Comparison of optical and electrochemical properties of anatase and brookite TiO₂ synthesized by the sol gel method", *J.Thin Solid Films*,vol. 403–404 (2002) 312, 2002.
- [14] DrummondIII, "C.H:Glass Formation and Crystallization in High Temperature Glass Ceramics and si₃n₄, *journal o*
- [15] J. Tschirch, D. Bahnemann, M. Wark, J. Rathouský, "A comparative study into the photocatalytic properties of thin mesoporous layers of TiO₂ with controlled mesoporosity", *J. Photochemistry and Photobiology A: Chemistry*,vol. 194 (2008)181, 2008
- [16] X. Ye, D. Chen, K. Li, V. Shah, M. Kesmez, K. Vajifdar, "Photocatalytic Oxidation of Aldehydes/PCE Using Porous Anatase Titania and Visible-Light-Responsive Brookite Titania", *Chem. Eng. Comm.*, 194: 368-381, 2007.
- [17] D. Grosso, G.J. Soler-Illia, A.A. de, E.L. Crepaldi, F. Cagnol, C. Sinturel, A. Bourgeois, A. Brunet-Bruneau, H. Amenitsch, P.A. Albouy, C. Sanchez, "Highly porous TiO₂ anatase optical thin films with cubic mesostructure stabilised at 700o c ", *J. Chem. Mater.* 24(2003)4562, 2003.
- [18] Magali Bonne, Stephane Pronier, Fabien Can, Xavier Courtois, Sabine Valange, Jean-Michel Tatibouet, Sebastien Royer, Patrice Marecot, Daniel Duprez, "Synthesis and characterization of high surface area TiO₂/SiO₂ mesostructured nanocomposite", *J.Solid State Sciences* ,vol. 12 (2010) 1002–1012, 2010
- [19] Angkhana Jaroenworarlucka, Nuchanaporn Pijarn, Nudthakarn Kosachan, Ron Stevens, "Nanocomposite TiO₂–SiO₂ gel for UV absorption", *J. Chemical Engineering* vol. 181– 182 (2012) 45– 55, 2012.
- [20] Babak Mazinani, Abdul Kadir Masrom, Ali Beitollahi, Rafael Luque, "Photocatalytic activity, surface area and phase modification of mesoporous SiO₂–TiO₂ prepared by a one-step hydrothermal procedure".



- [21] M., Saito, "Antibacterial, Deodorizing, and UV Absorbing Materials Obtained with Zinc Oxide (ZnO) Coated Fabrics, Journal of Coated Fabrics", 23: p. 150-164, 1993
- [22] H.Y. Yang, S.K. Zhu, and N. Pan, "Studying the Mechanisms of Titanium Dioxide as Ultraviolet-Blocking Additive for Films and Fabrics by an Improved Scheme", Journal of Applied Polymer Science, 92: p. 3201-3210, 2003
- [23] H.Y Chien, H.W.Chen, and C.C. Wang," The study of non-formaldehyde crease-resist finishing fabrics treated with the compound catalyst of nanometer grade TiO₂ under UV light and different polycarboxylic acid", Journal of the Hwa Gang Textile, 10: p. 104-114, 2003C.C. Wang, and C.C. Chen, "Physical properties of crosslinked cellulose catalyzed with nano titanium dioxide", Journal of Applied Polymer Science, 97: p. 2450-2456, 2005
- [24] X.Q. Song, A. Liu, C.T.Ji, , and H.T. Li," The effect of nano-particle concentration and heating time in the anti-crinkle treatment of silk", Journal of Jilin Institute of Technology, 2001. 22: p. 24-27.





10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)